Telephony

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Mathematics For Telephone Engineers

By H. H. HARRISON, M. Eng., M. I. E. E.

FIFTH ARTICLE OF SERIES on mathematics, especially written to aid telephone engineers in handling alternating current problems. This section discusses the theory of permutations and combinations and its use in proving the binomial theorem and also in dealing with probability problems as used by telephone engineers to calculate switch quantities from traffic data. The four preceding articles in this series were published in the issues of TELEPHONY of May 30, June 27, July 25 and August 29, respectively

EACH OF the groups which can be made by taking some or all of a number of things is called a *Combination*. ab, bc, abc, a, abcd, are all combinations of the four letters *abcd*.

If there are n different things and each group contains r of them, the symbol nCr is used to denote the number of these groups and is read "the combinations C of n things r at a time."

Example 1:

4C2.

$n = 4$

$r = 2$

Supposing that n represents the four letters *a*, *b*, *c*, *d*. They can be formed into groups two at a time thus: *ab*, *ac*, *ad*, *bc*, *bd*, *cd*.

Therefore, $4C2 = 6 = \dfrac{4 \times 3}{1 \times 2}$.

Five things, say the letters *a*, *b*, *c*, *d* and *e*, can be grouped three at a time forming, *abc*, *abd*, *abe*, *acd*, *ace*, *ade*, *bcd*, *bce*, *bde*, *cde*. That is ten groups in all, and $5C3 = 10 = 5.4.3/1.2.3$.

If a combination such as *abc* has the *order* of its letters changed, every possible *arrangement* is called a *Permutation*. *abc* yields the following permutations:

abc, acb, bac, bca, cab, cba.

If there are n things and each arrangement contains r of them, the symbol nPr is used to denote the number of such arrangements. Take the letters *a.b.c.d* and let $r = 2$, then, what is the value of 4P2?

From example 1 the number of combinations two at a time is 6; and each such combination furnishes two arrangements (ab, ba; ac, ca; ..... etc.).

Therefore, $4P2 = 4C2 \times 2 = 12$.

If one operation can be effected in n ways and when it has been completed, a second operation can be effected in p ways, the number of ways of performing the two operations together is $n \times p$.

Supposing that on a ship two lookout men (one forward and one aft) are to be chosen from a group of 5 men. The number of ways in which one can be chosen for the forward position is 5. After the choice of the first man there now remains 4 ways of choosing the man for the aft lookout point.

For each of the five selections for the forward man there can be anyone of four men chosen for the aft position and, therefore, the total number of different arrangements of the men will be $5 \times 4 = 20$.

Assume a selection of r things is to be made from a total of n. The first selection can be made in n ways. The second selection (the first having been made) can only be made in $(n-1)$ ways. Hence the number of ways in which the first and second selections can be made is $n(n-1)$. The first, second, and third selections can be made in $n(n-1)\ (n-2)$ ways and so on.

The r selections can be made in $n(n-1)\ (n-2)$.....to r factors.

If there are three factors, the last one $=(n-3+1)$. If there are four factors, the last $=(n-3)=(n-4+1)$. Therefore, when there are r factors, the last is $(n-r+1)$.

Therefore, the number of permutations of n things taken r at a time is $nPr = n\,(n-1)\ (n-2)\ldots\ldots(n-r+1)$.

If $r = n$,

$$nPn = n(n-1)\ (n-2)\ldots\ldots (n-n+2)\ (n-n+1)$$
$$= n(n-1)\ (n-2)\ldots\ldots 2.1$$

Thus, $5P5 = 5.4.3.2.1$.

This continuous product is termed *factorial* n and is written $\angle$n or n!

Factorial $5 = \angle 5 = 1.2.3.4.5 = 120$.

From the method of obtaining the permutations in any case, that for determining the number of combinations may be derived.

It is clear that nCr will be less than nPr since each group or combination will yield at least two permutations.

For groups of r things, the different arrangements in each must be $\angle r$ (r things taken r at a time). Hence the

number of permutations is, $\angle r \times$ the number of combinations or,

$$nPr = \angle r \times nCr$$

Therefore,

$$nCr = nPr/\angle r$$
$$= n(n-1)(n-2)\ldots\ldots (n-r+1)/1.2.3\ldots\ldots r \quad (1)$$

The expression for nPr, i. e. $n(n-1)(n-2)\ldots\ldots(n-r+1)$ is not equal to $\angle n$ but is less than this by the factors $(n-r)$, $(n-r-1)$, $(n-r-2)$ ..... to 1. Since each factor is n diminished by one more than the previous factor, the factor following $(n-r+1)$ is $(n-r)$; that following $(n-r)$ is $(n-r-1)$ and so on. The deficit from $\angle n$ is obviously $\angle n-r$.

Multiplying (1) top and bottom by $\angle n-r$,

$$nCr = n(n-1)(n-2)\ldots\ldots (n-r+1)(n-r)\ldots\ldots$$
$$2.1/\angle r \times \angle n-r$$
$$= \angle n/\angle r\,\angle n-r$$

Each time a group of r things is selected from n things, $n-r$ things are left. Therefore,

$$nCr = nCn-r$$

This equation is frequently used to reduce the labor of calculation. Example: What is the value of 60C58?

Since $nCr = nC\ n-r$

$60C\,58 = 60.59/1.2 = 1770$.

If this were worked out by means of (1) the arithmetical work involved would be found to be almost prohibitive.

A knowledge of the theory of permutations and combinations is necessary in order to prove the binomial theorem and it will also be found useful in dealing with probability problems as used by the telephone engineer to calculate switch quantities from traffic data.

The Binomial Theorem

The product of any two algebraic binomial expressions is equal to the sum of the products obtained by multiplying every term of one by every term of the other. Thus,

$$(a+b)\ (c+d) = ac + bc + ad + bd$$

The continued product of several binomial expressions is obtained by taking the product of any two of them and then multiplying this by a third expression and so on.

Example:

$$(x+a) \times (x+b) \times (x+c)$$
$$x+a$$
$$x+b$$
$$x^2 + ax + bx + ab$$
$$= x^n + x^{n-1}(a+b) + x^{n-2}\,ab$$ where $n=2$ $(x^{n-2} = x^0 = 1)$

Again,

$$x^2 + x(a+b) + ab \times (x+c) = x^3 + x^2(a+b) + abx + x^2c + cx(a+b) + abc$$
$$= x^3 + x^2(a+b+c) + c(ab+ac+bc) + abc$$
$$= x^n + x^{n-1}(a+b+c) + x^{n-2}(ab+ac+bc) + x^{n-3}\,abc$$

where $n=3$

It will be noted that the first term is obtained by taking x out of each factor, thereby obtaining x^n. The second term is obtained by taking x out of all the brackets with the exception of one giving x^{n-1} and multiplying this by the letters $a.b.c.$ Thus, $x^{n-1}(a+b+c\ldots\ldots)$ to n terms.

The third term is obtained by taking x from all the brackets but two (x^{n-2}) and multiplying this by the products of the letters a, b, c..... taken two at a time. The third term is thus $x^{n-2}\ (ab+ac+bc)$.

The fourth term is the product abc simply, since x^{n-3} is $x^0 = 1$ when $n=3$.

Now let $a=b=c$..... Then, $(x+a)^4$ is,

$$x+a$$
$$x+a$$
$$x^2 + x(a+a) + a^2$$
$$x+a$$
$$x^3 + x^2(a+a) + a^2x + x^2a + (a^2+a^2)x + a^3$$
$$x^3 + x^2(a+a+a) + x(a^2+a^2+a^2) + a^3$$
$$x+a$$
$$x^4 + 3x^3a + x^3a + 3x^2a^2 + x^2a^2 + 3xa^3 + a^4$$
$$= x^n + 4x^{n-1}a + 6x^{n-2}a^2 + 4xa^3 + 4x^{n-3}a^3 + x^{n-4}a^4$$

It will be seen that the powers of x decrease by one term by term, x decreasing from x^n to $x^0 = 1$ while a increases term by term from $a^0 = 1$ to a^n. Intermediate terms have a numerical coefficient affixed to them and if it is possible to assign values to these coefficients whatever the index n may be, a general method of expanding any binomial such as $(x+a)^n$ is arrived at.

From the preceding example letter x is taken every time—that is, n times—to form one term of the product, and this can only be done in one way. Therefore, x^n is a term of the product. a can be taken once while x can be taken the remaining $(n-1)$ times; and the number of ways in which one a can be taken is the number of ways of taking one out of n things, i. e., $nC1$.

The second term is, therefore, $nC1\ x^{n-1}a$. Since $n=4$, $nC1 = 4$. Further, the letter a can be taken twice and x the remaining $(n-2)$ times. The number of ways in which two a's (a^2) can be taken is the number of ways of taking 2 out of n things, i. e., $nC2$. The third term is, therefore,

$$nC2\ x^{n-2}a^2 = n(n-2)/\angle 2 \times x^{n-2}a^2$$
$$= 4.3/1.2 \times x^{n-2}a^2$$
$$= 6x^{n-2}a^2.$$

In the fourth term the letter a can be taken three times $(a \times a \times a = a^3)$ and the number of ways in which a^3 can be taken is the number of ways of taking 3 out of n things.

The fourth term is thus

$$nC3 \times x^{n-3}a^3. = 4.3.2/1.2.3 \times x^{n-3}a^3 = 4x^{n-3}a^3$$

The fifth and last term is obtained by taking four a's out of the brackets. The coefficient here is unity since $nCr = nC\ n-r$ and, therefore, $nCn = nCn-n = nCo = 1$.

It would, therefore, appear that the general expression for $(x+a)^n$ is

$$x^n + nC1\ x^{n-1}a + nC2\ x^{n-2}a^2 \ldots\ldots + \angle n/\angle r\angle n-r \times x^{n-r}a^r \ldots\ldots + a^n \quad \ldots\ldots (2)$$

The reader should refer to the standard books for proofs that the theorem is true for all values of n.

Expand $(x+a)^{-1}$.

$$(x+a)^{-1} = x^{-1} + \frac{-1}{1}x^{-1-1}a + \frac{-1(-1-1)}{1+2}x^{-1-2}a^2 + \frac{-1(-1-1)(-1-2)}{1\times 2\times 3}x^{-1-3}a^3 \ldots.$$

or $1/(a+x) = 1/x - a/x^2 + a^2/x^3 - a^3/x^4$.

The theorem is true if n has the values 1/2, 1/3, 1/7, 1/11, etc.

Thus $(x+a)^{1/2}$ or $\sqrt{x+a}$ expands to

$$x^{1/2} + 1/2\ x^{1/2-1} + 1/2\ (1/2-1)/1 \times 2\ x^{1/2-2}a^2 \ldots\ldots \text{etc.}$$

$$(x+a)^{2/3} = x^{2/3} + 2/3\ x^{2/3-1}a + \frac{2/3(2/3-1)}{1\times 2}x^{2/3-2}a^2 \ldots\ldots \text{etc.}$$

Expand $1/3\sqrt{(x+a)^2} = 1/(x+a^{2/3} = (x+a)^{-2/3}$.

$$= x^{-2/3} - 2/3\ x^{-5/3}a + \frac{2/3\times 5/3}{1\times 2}x^{-8/3}a^2 \ldots\ldots \text{etc.}$$

$$= \frac{1}{x^{2/3}} - \frac{2a}{3x^{5/3}} + \frac{5a^2}{9x^{8/3}} \ldots\ldots$$

If the second term of the binomial is small compared with the first, the successive terms become smaller and smaller and the expansion is said to be *convergent*.

Example: $(x+a)^n$. The successive terms contain 1 or a^0, a^1, a^2, a^3, etc.

Writing $(x+a)^n = x(1+a/x)^n$
$= x^n(1+a/x)^n$

Then since a is less than x, a/x is a fraction whose powers get smaller as its exponents increase.

The following examples illustrate the utility of the binomial theorem. Example 1: Calculate $(1.003)^5$ to five places of decimals.

$(1.003)^5 = 1 + 3/1000)^5$
$= 1^5 + 8 \times 1^7 \times 3/1000 + 8 \times 7/1 \times 2 \times 1^6(3/1000)^2 + 8 \times 7 \times 6/1 \times 2 \times 3 \times 1^5(3/1000)^3 + \ldots\ldots$
$= 1 + .024 + .000252 + .000001512$
$= 1.02425$

Example 2: $\sqrt[5]{268}$.

$2^8 = 256$, therefore

$\sqrt[5]{268} = \sqrt[5]{(2^8 + 12)}$
$= [2^8(1 + 12/2^8)]^{1/5}$
$= 2(1 + 12/2^8)^{1/5}$
$= 2(1 + 3/2^6)^{1/5}$
$= 2[1 + 3/64]^{1/5}$
$= 2\Big[1 + 1/8 \times 1^{(1/5-1)} \times 3/64 + \frac{1/8(1/8-1)}{1 \times 2} \times 1^{1/5-2}(3/64)^2 + \frac{1/8(1/8-1)(1/8-2)}{1 \times 2 \times 3} \times 1^{(1/5-3)}(3/64)^3 \ldots\ldots\Big]$
$= 2[1 + .0058 - .000012\ldots\ldots]$
$= 2.0116$

Note: Since $x = 1$, all powers of $x = 1$.

In the expression $(1+a)^n$ if a is small compared with 1 and n is within the limits of $+2$ and -2, the terms of the expansion rapidly become smaller and smaller. Thus in

$$1 + na + \frac{n(n-1)}{\angle 2} + \text{etc.,}$$

a first approximation is obtained by taking the first two terms of the expansion and

$(1+a)^n = 1 + na$ approximately
$(1-a)^n = 1 - na$ approximately
$(1+a)^{-n} = 1 - na$ approximately
$(1-a)^{-n} = 1 + na$ approximately

If greater accuracy is desired, the first three terms may be taken thus obtaining a second approximation.

These second approximations are:

$(1+a)^n = 1 + na + 1/2 \times n(n-1)a^2$ approximately
$(1-a)^n = 1 - na + 1/2 \times n(n-1)a^2$ approximately
$(1+a)^{-n} = 1 - na + 1/2 \times n(n+1)a^2$ approximately
$(1-a)^{-n} = 1 + na + 1/2 \times n(n+1)a^2$ approximately

Example 1: $\sqrt[3]{1009}$

$\sqrt[3]{1009} = (1000 + 9)^{1/3}$
$= 10(1 + 9/1000)^{1/3}$
$n = 1/3,\ na = 9/3000 = .003$
$\sqrt[3]{(1009)} = 10(1 + .003 = 10.003$

The third term in the binomial expansion is, $1/2 \times 1/3 \times (-2/3) \times (9/1000)^2$.

This is

$1/2 \times 1/3 \times (-2/3) \times 81/10^6 = -.00000891$

and the second approximation is, therefore, $10.03 - .00000891 = 10.029\ldots\ldots$

Example 2: $\sqrt[4]{600}$

$\sqrt[4]{600} = (625 - 25)^{1/4}$
$= 5(1 - 25/625)^{1/4}$
$n = 1/4,\ na = .01$

Therefore, $\sqrt[4]{600} = 5(1 - .01) = 4.95$.

The third term is

$-(1/2 \times 1/4 \times 3/4 \times (1/25)^2$
$= -.031 \times .0016$
$= .0000496$

The second approximation is, therefore, $4.9499\ldots\ldots$

The Exponential Series

Writing $a = 1/n$, the expansion of $(1+a)^n$, repeated here for reference, is

$$1 + na + = \frac{n(n-1)}{1.2}a^2 + \frac{n(n-1)(n-2)}{\angle 3}a^3 \ldots\ldots$$

and,

$(1 + 1/n)^n$
$= 1 + n \times 1/n + \frac{n(n-1)}{\angle 2}(1/n)^2 + \frac{n(n-1)(n-2)}{\angle 3}(1/n)^3 \ldots\ldots$
$= 1 + 1 + \frac{(1-1/n)}{\angle 2} + \frac{(1-1/n)(1-2/n)}{\angle 3} + \ldots\ldots$

Supposing n to grow indefinitely, then as $n \to \infty$ (n approaches infinity) all fractions having n for denominator become infinitely small and can be neglected. Thus, in the limit—n infinity—the right-hand side of the last expression becomes:

$1 + 1 + 1/1.2 + 1/1.2.3 + 1/1.2.3.4 \ldots\ldots (1)$

The value of this series can be found correctly to as many figures as desired. The various terms are:

	1.000000
Dividing by 1	1.000000
Dividing by 2	.500000
Dividing by 3	.166667
Dividing by 4	.041667
Dividing by 5	.008333
Dividing by 6	.001389
Dividing by 7	.000198
Dividing by 8	.000025
Dividing by 9	.000003
	2.718282

This number is usually represented by the letter e or ϵ. It is easy to see that ϵ is the limit of the series (1) by giving n various values. Thus,

$(1 + 1/2)^2 = 2.25$
$(1 + 1/5)^5 = 2.489$
$(1 + 1/10)^{10} = 2.594$
$(1 + 1/20)^{20} = 2.653$
$(1 + 1/100)^{100} = 2.704$
$(1 + 1/1000)^{1000} = 2.7171$
$(1 + 1/10{,}000)^{10000} = 2.7182$ and so on.

Another series which is useful is that representing the expansion of ϵ^x.

Now $(1 + 1/n)^{nx} = [(1 + 1/n)^{nx}] = \epsilon^x$ when n is made infinitely great.

Expanding $(1 + 1/n)^{nx}$ by the binomial theorem,

$(1 + 1/n)^{nx}$
$= 1 + nx \cdot 1/n + \frac{nx(nx-1)}{\angle 2} \cdot \frac{1}{n^2} + \frac{nx(nx-1)(nx-2)}{\angle 3} \cdot \frac{1}{n^3} \ldots\ldots$
$= 1 + x + \frac{x(x-1/n)}{\angle 2} + \frac{x(x-1/n)(x-2/n)}{\angle 3} + \ldots\ldots$

Making n indefinitely great,

$(1 + 1/n)^{nx} = \epsilon^x = 1 + x + x^2/1.2 + x^3/1.2.3 \ldots\ldots$

Let $x = 1/2$, then

$\epsilon^{1/2} = 1 + 1/2 + 1/2^2\angle 2 + 1/2^3\angle 3 \ldots\ldots$

Dividing by 2	1.000000
Dividing by 4	.500000
Dividing by 6	.125000
Dividing by 8	.020833
Dividing by 10	.002604
Dividing by 12	.000260
Dividing by 14	.000022
	.000002
	1.648721

$\epsilon^{1/2} = 1.648721 \ldots\ldots$

$\log_\epsilon 1.648721 = 1/2$ and the series ϵ^x can be used to calculate a series of numbers if the logarithms to the base ϵ are known. ϵ is, therefore, the base of a system of logarithms called Napierian or hyperbolic logs. When

$x = 1,\ y = 2.718281 = \epsilon$
$x = 2,\ y = (2.718281)^2 = \epsilon^2$
$x = 3,\ y = (2.718281)^3 = \epsilon^3$
$x = x,\ y = (2.718281)^x = \epsilon^x$

The reader may be pardoned for not, at this stage, seeing much utility in the binomial theorem and exponential series. Their value will be more apparent to him as he proceeds.

Elementary Theory of Probability

Although Probability has no connection with the mathematics of telephone transmission, it is a subject of considerable importance to telephone engineers who are interested in telephone traffic. Its introduction here is due to the fact that some of the theorems which have been established in this section are directly applicable to probability problems. On this account, the digression may be excused.

If a coin is spun, the chance of one side or the other coming down depends upon a number of causes. These do not favor either one side or the other; and if a large number of spins are made, one side will come down as many times, approximately, as the other.

As the number of spins is increased, the divergence between the appearances of one side or the other may increase but the ratio of divergence to the number of spins will decrease.

If a six-sided die is thrown, the appearance of any one of the six faces is equally likely and there will be approximate equality between the number of appearances of each in a series of throws.

If an event can happen in a ways and fail in b ways and these ways are equally likely to occur, the probability of its happening is $a/a+b$ and of failing, $b/a+b$.

The probability of an event occurring is found by determining the ratio of the actual number of times it occurs in a large number of cases to the whole number of times in which it occurs and in which it fails.

If an event is *certain*, it will occur without fail in every case. Its probability is a/a (b being zero)$=1$ or unity. If p is the probability of an event occurring, $1-p$ will be the probability of its failing to occur.

Example 1: Find the probability of throwing 3 with an ordinary six-faced die.

Since any one face is as likely to be exposed as any other, there is one favorable and five unfavorable cases which are all equally likely. Therefore, the required probability is

$$a/a+b = 1/1+5 = 1/6.$$

Example 2: Find the chance of throwing an odd number with an ordinary die.

There are three favorable cases and three unfavorable,

Therefore, $p = 3/3+3 = 1/2$.

Example 3: What is the chance of drawing a red ball from a bag containing 6 white and 5 red balls?

Any one ball is as likely to be drawn as any other. Thus there are five favorable and six unfavorable cases. The required probability is, therefore, 5/11.

Example 4: Two balls are to be drawn from a bag containing 6 white and 5 red balls. What is the probability that they will both be red?

Any one pair of balls is as likely to be drawn as any other pair. The total possible number of pairs is 11C2. The number of pairs which are red is 5C2.

p = number of favorable cases/total number of cases and this is

$$\frac{5.4}{1.2} \Big/ \frac{11.10}{1.2} = 10/55 = 2/11$$

The odds against the event happening are 9:2.

Independent Events

The probability that two independent events should both happen is the product of the separate possibilities of their happening.

Assume that the first event can happen in a_1 and fail in b_1 equally likely ways and that the second event can happen in a_2 and fail in b_2 equally likely ways. Then, each of the a_1+b_1 cases can be associated with each of the a_2+b_2 cases, making $(a_1+b_1)(a_2+b_2)$ compound cases which are equally likely and in a_1a_2 of these cases both events happen. Hence the probability that both events happen is:

$$\frac{a_1a_2}{(a_1+b_1)(a_2+b_2)} = \frac{a_1}{(a_1+b_1)} \times \frac{a_2}{(a_2+b_2)}$$

The probability of concurrence of two independent events having probabilities p_1 and p_2 is $p_1 \times p_2$.

If p is the probability that the event would happen in one trial, the chance that it will happen in r trials is $pxpxpx \ldots$ to r factors, i.e., p^r.

Example 1: Find the probability of throwing an ace twice running with a six-faced die.

$$r = 2,\ p = 1/6$$

Therefore, the required probability is $1/6 \times 1/6 = (1/6)^2 = 1/36$.

If p is the probability of an event happening, the probability of failure is $1-p=q$.

Assume that six throws are made with a six-sided die, the probability that 1 appears in the second and sixth throws is $p1 = 1/6.1/6 \ldots . (1)$.

The probability that 1 does not appear at the first, third, fourth and fifth throw is $p_2 = (5/6)^4 \ldots . (2)$.

The probability that 1 appears with the second and sixth throw and does not appear with the other four throws is

$$p_3 = p_1 \times p_2 = (1/6)^2 \times (5/6)^4 = p^r.q^{n-r} \ldots . . (3)$$

p_3 is the probability of its happening r times and failing $n-r$ times. But the total number of ways in which the event could happen r times exactly in n trials is nCr and these are all equally likely.

Thus, if $(p+q)^n$ be expanded by the binomial theorem, successive terms will be the probability of the event happening exactly n times, $n-1$ times, $n-2$ times, etc., in n trials.

If the event happens n times or fails only once, twice $\ldots . n-r$ times, it happens r times or more. Therefore, the chance that it happens *at least* r times in n trials is

$$p^n + n\text{C}1\ p^{n-1}q + n\text{C}2\ p^{n-2}q^2 \ldots . n\text{C}n-r\ p^rq^{n-r} \quad (4)$$

or the first $n-r+1$ terms of the expansion of $(p+q)^n$.

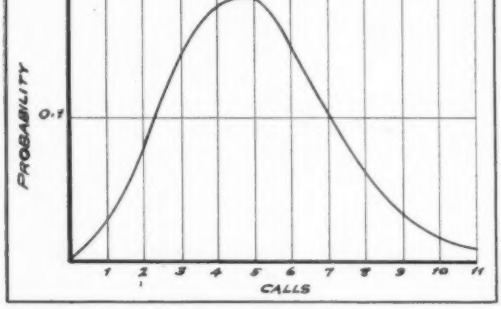
G. T. Blood of the A. T. & T. Co. found in 1898 that some agreement existed approximately between the terms of a binomial expansion and observations on the distribution of busy-hour calls. In 1907, W. H. Grinsted applied the theory of probability to the computation of switch quantities to deal with a definite amount of traffic. The expression (4) is cumbersome to deal with but the series can be reduced to a comparatively simple form as follows:

$$(q+p)^n = q^n + nq^{n-1}p + \frac{n(n-1)q^{n-2}p^2 \ldots . + p^n}{\angle 2} \quad (5)$$

$$= q^n \left\{ 1 + \frac{np}{q} + \frac{n(n-1)p^2}{\angle 2\,q^2} + \ldots . \frac{n(n-1)\ldots .(n-r+1)}{\angle r\,q^r}\,p^r + \frac{p^n}{q^n} \right\} \quad (6)$$

Let n approach infinity and p zero so that $np=m$, or $p=m/n$ and $n=m/p$. Then, $q=(1-p)=(1-m/n)$

As $n \to \infty$, $q \to 1$ and $(1-m/n) \to 1$



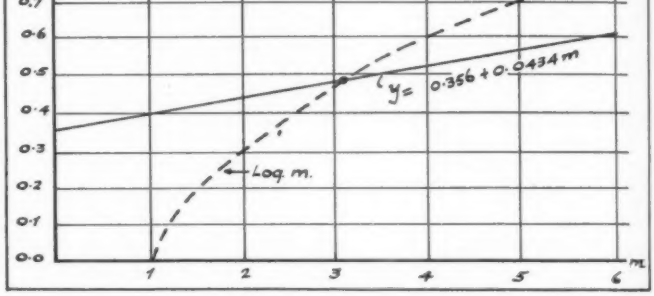


Fig. 29, Curve Showing the Probabilities of Different Numbers of Calls Occurring. On Right is Fig. 30, Curve Showing Graphic Solution of Calculation of Amount of Traffic Carried by 10 Trunks With a Loss of 1 Call in 1,000.

Also, $n(n-1) \rightarrow n^2$, $n(n-1)\ (n-2) \rightarrow n^3$, etc.

Therefore,

$$q^n = (1-p)n = (1-p)^{m/p}$$

and (6) becomes,

$$(1-p)^{m/p} \quad 1 + m + m^2/\angle 2 + \ldots.$$
$$m^r/\angle r \qquad + m^n/\angle n \quad (7)$$

It has been shown previously that $(1-x)^{1/x} = e^{-1}$ when $x \rightarrow 0$. Therefore, $(1-p)^{m/p} = e^{-m}$ and (7) can be written

$$e^{-m}\,[1 + m + m^2/\angle 2 + \ldots. m^r/\angle r \ldots. + m^n/\angle n]$$

$$\text{or } e^{-m} + me^{-m} + \frac{m^2}{\angle 2} e^{-m} \ldots.$$

$$\frac{m^r}{\angle r} e^{-m} + \ldots. \frac{m^n}{\angle n} e^{-m} \qquad (8)$$

This is the exponential binomial limit due to Poisson, the general term of which is

$$\frac{m^x e^{-m}}{\angle x}$$

Applying this to telephone traffic calculations, W. H. Grinsted showed that if:

m = the *average* number of calls in a given time interval

x = the number of calls occurring during that interval

p = the probability of x calls occurring, then,

$$p = \frac{e^{-m}m^x}{\angle x}$$

Thus, let $m = 5$, the probability that 1, 2, 3,.....n calls occur in the interval will be obtained by substituting these figures in the general term of (8)

The probability, for example, of 3 calls occurring is

$$p = e^{-5} \times 5^3/1 \,.\, 2 \,.\, 3$$
$$= .0067 \times 125/6 = .1396$$

The curve of Fig. 29 shows the probabilities of different numbers of calls occurring, the maximum probability being for the average number of calls, as is to be expected.

The same formula can be used for calculating the amount of traffic carried by a group of N trunks with a given probability of loss.

Let

$p = .001$, i. e., 1 call lost per 1,000

$N = 10$

m = the average number of calls per interval as before, then,

$.001 = e^{-m} \times m^{10}/\angle 10$ and

$\log P = 10 \log. m - m \log. e - \log. \angle 10.$

The common log. of $\angle 10 = 6.5598$

$\log. e = .4343$

$-3 = 10 \log. m - m \times .4343 - 6.5598$

$0.356 = \log. m - .04343\ m.$

This is best solved graphically; and from Fig. 30 the curves for log. m and for $0.356 + 0.04343\ m$ are seen to cut one another at $x = 3.1$, indicating that ten trunks will carry an average of 3.1 calls with a loss of one call in 1,000. This means that one call will occur in 1,000 at a time that all trunks are occupied and it will, therefore, be lost.

The interested reader will obtain results for 20, 30, 40, 50 and 100 trunks and plot his results in a curve which will show the effect of the size of trunks groups on traffic-carrying capacity.

The telephone engineer is greatly indebted to the pioneer work of Blood and Grinsted and it is hoped that this digression will enable the student to read with some understanding the writings of their successors such as Erlang, Lubberger, O'Dell, Molina and Fry.

▼ ▼

Exhibitors' Reservations for National Convention

Arrangements are being completed for the annual convention of the United States Independent Telephone Association which is to be held during Independent Telephone Week, October 13-16, at the Stevens Hotel, Chicago.

The arrangements for the convention meetings are the same as they were last year, with the registration desk and exhibitors' headquarters on the 25th floor of the hotel and the meetings in the Tower Room. The size of exhibits are confined to small exhibits such as the rooms will accommodate.

Reports coming to association's offices at 19 S. La Salle St., Chicago, indicate that the attendance at the convention next month will be the largest for a number of years. With the gathering of the Independents about five weeks away 44 exhibitors have arranged for space. At the convention last fall there was a total of 45 exhibitors so this year's meeting will undoubtedly establish new records as to number and variety of exhibits.

The organizations which have already engaged exhibit rooms are:

Albertson Electric Co., Milwaukee, Wis.

American Automatic Electric Sales Co., Chicago, Ill.

L. M. Berry & Co., Dayton, Ohio.

Buckeye Telephone & Supply Co., Columbus, Ohio.

A. B. Chance Co., Centralia, Mo.

Churchill Cabinet Co., Chicago Ill.

Coffing Hoist Co., Danville, Ill.

Cook Electric Co., Chicago, Ill.

Cuneo Press, Inc., Chicago, Ill.

Do More Chair Co., Elkhart, Ind.

R. R. Donnelley & Sons Co., Chicago.

Electric Products Co., Cleveland, Ohio.

Electric Storage Battery Co., Philadelphia, Pa.

Everstick Anchor Co., Fairfax, Iowa.

Fansteel Metallurgical Corp., North Chicago, Ill.

Fernand De Gueldre Studios, Chicago, Ill.

Gould Storage Battery Corp., Depew, N. Y.

Gustav Hirsch Organization, Columbus, Ohio.

Holtzer-Cabot Electric Co., Chicago, Ill.

Inland Equipment Co., Indianapolis, Ind.

J. K. Johnston, Indianapolis, Ind.

Kellogg Switchboard & Supply Co., Chicago, Ill.

Leich Electric Co., Genoa, Ill.

Lenz Electric Mfg. Co., Chicago, Ill.

Loomis Advertising Co., Kansas City, Mo.

Lorain Products Corp. Lorain, Ohio.

National Carbon Co., New York City.

National Telephone Supply Co., Cleveland, Ohio.

North Electric Mfg. Co., Galion, Ohio.

Page & Hill Co., Minneapolis, Minn.

Postal Telegraph & Cable Co., New York City.

Ray-O-Vac Co., Madison, Wis.

Reliable Electric Co., Chicago, Ill.

John A. Roebling's Sons Co., Trenton, N J.

Runzel Cord & Wire Co., Chicago, Ill.

Schauer Machine Co., Cincinnati, Ohio.

Signaphone Corp. of America, New York City.

Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.

Suttle Equipment Co., Lawrenceville, Ill.

Telephonads, Chicago, Ill.

Telephone Engineer Publishing Co., Chicago, Ill.

Telephony Publishing Corp., Chicago, Ill.

The Telephone Repair Shop, Chicago, Ill.

Wisconsin Cuneo Press.

▼ ▼

Big Cable Repair Job Done in Record Time

The efficiency of telephone workers was exemplified in a remarkable way recently in Newark, N. J., when a 600-volt electric cable suddenly went "haywire" underground at one of the city's busiest corners. Electrical forces tore and ripped out iron pipes and tiers of cable conduits, as well as fusing fine copper wires and melting the leaden sheaths from six great cables.

The net result was to put hundreds of telephones in one community out of service and to interfere seriously with trunk service between a number of towns in northern New Jersey and Newark and New York City.

Within a few minutes the repair crew of the New Jersey Bell Telephone Co. was on the spot, armed with high-speed machines. They dug, they sawed, they cut, they tore, they rewired and they spliced—and soon the job was done. The explosion occurred on a Monday noon and at midnight of the following day the service was completely restored.

IN THE NATION'S CAPITAL

By FRANCIS X. WELCH,
Special Washington Correspondent for TELEPHONY

"WHAT the public is entitled to demand is that no more be exacted from it for the use of a public highway than the services rendered by it (a railroad carrier) are reasonably worth."—Smyth v. Ames, 169 U. S. 466.

The foregoing sentence, from an opinion written back in 1898 by Mr. Justice Harlan, is probably the most mischievous passage that ever occurred in a ruling case by the United States Supreme Court on the subject of utility regulation.

Time and again conservative analysts have insisted that Justice Harlan was merely referring—in somewhat obscure language, perhaps—to the perfectly obvious fact that whatever may be the cost of service to a utility, the price cannot exceed the value of the service to the customer for the simple reason that the customer would soon stop using it.

In other words, it was argued that the "value of service" as a limitation on utility rate making was a self-enforcing rule of economics rather than a regulatory rule to be adopted and enforced by the courts. A utility that violated this fundamental rule of economics by raising rates above the value of its service to the public, would soon lose its customers and become defunct. There was little that the courts could do or needed to do about it.

SUCH was the prevailing legal view forcefully laid down and discussed by Dr. H. W. Edgerton as early as 1919 ("Value of Service as a Factor in Rate Making," 32 Harvard Law Review 516) and repeatedly followed by the lower Federal courts. As recently as March, 1934, a three-judge Federal court in Georgia Power Co. v. Georgia Public Service Commission (8 Federal Supp. 603) repudiated the argument that a utility could possibly be charging more for its service than it was worth and still do business.

Said the court: "If the complainant's service is costing more than it is worth, we see no remedy but for customers to find a substitute. It cannot constitutionally be compelled by the state without just compensation."

Just the same there were dissenters, mostly legal liberals, who saw in Justice Harlan's cryptic remark a loophole by which utility rates could be restricted without necessarily paying homage to fair value, fair return, operating expenses, and the other routine factors that have to be weighed in the conventional rate proceeding. Until the depression set in, these dissenters confined their reasoning mostly to legal reviews, economic journals and other literary outlets.

"Why," they asked, "did Justice Harlan say such a thing if he didn't mean it. If he were simply referring to the automatic function of economic forces of supply and demand, why did he not say so?" Examples of "value of service" as a basis for rate fixing in England and other European countries were reviewed.

WHEN the depression came, however, there developed—as we all know—widespread agitation throughout the United States for reduced rates for all forms of utility service. Telephone companies were particularly hard hit. Patrons began to desert the service of utilities which failed to offer some relief by way of rate reductions. Then came the Wisconsin Telephone Co. case of 1932 in which for the first time the ability of the consumer to pay as a basis for fixing rates was frankly discussed by the Wisconsin commission (P.U.R. 1932D, 173).

Critics of utility rates far and wide hailed the decision (TELEPHONY of July 9, 1932) as a clean-cut test of whether the value of service would have any standing in court as a basis for rate fixing. This correspondent remembers very well the discussion at that time and recalls that he himself was unable to concur with the prevailing view that the Wisconsin commission had struck out for a new principle in regulation.

IT IS TRUE the commission opinion discussed the "value of service" and the "customer's ability to pay" at great length. It was strongly urged that where large numbers of patrons, by reason of reduced earning power, could not afford to continue service, public interest demanded relief by way of rate reduction. However, the opinion, written by the able but canny commissioner, David Lilienthal (now of the TVA) went on to urge other and different reasons for cutting the telephone company's rates, so that in the end one could not say for certain just what was the principal basis of the commission's order.

A few other cases happened later that seemed to present more clean-cut tests. For instance, the decision of the Maine Supreme Court in Gay et al. v. Damariscotta-Newcastle Water Co. (131 Me. 304, P.U.R. 1932E, 300). But the Wisconsin Telephone Co. case was the only one that showed any promise of getting the annoying value-of-service question before the United States Supreme Court.

Unfortunately, even the doubtful test offered by the Wisconsin Telephone Co. case is now impossible. In the court litigation that followed the original 12½ per cent "emergency rate cut" of 1932, the value-of-service issue has been lost in the shuffle. The most recent order of the commission was that made on March 24, 1936 (TELEPHONY of March 28, 1936; 13 P.U.R. (N.S.) 224), modifying the rate cut to 8 per cent of revenues and shifting the basis of the order away from all reliance on value-of-service.

This order involves issues concerning property values, operating expenses, fluctuating price levels, and such run-of-the-mill stuff. Whether it eventually stands up or falls down on such grounds, it will be only another important rate case. The Wisconsin commission has marched up the hill and marched down again. Furthermore, now that economic recovery is beginning to bring back subscriber installations, the argument about patronage diminution has lost its force; and so we will probably never have the issue finally settled until another depression hits us.

Aside from value of service, however, the Wisconsin commission's most recent opinion in the Wisconsin Telephone Co. case includes a number of important potential points if, as and when the United States Supreme Court finally rules on its merits. As stated above, these are not innovations but they are, nevertheless, important if for no other reason than the impressive weight of research thrown behind the case by the commission staff.

Viewed in its entirety, the Wis-

consin telephone rate case may yet become the Iliad of regulation. Other commissions have had important Bell telephone rate cases: Illinois, Maryland, Michigan, Ohio and New York —to mention the more prominent of recent memory. In this correspondent's opinion, however, in no other state-wide telephone rate case has a state public service commission gone to the mat in such a thorough fashion as in Wisconsin.

WITHOUT attempting to rehash or digest the commission's elaborate decision, which may be read by anyone in the printed reports, consider what this one state commission accomplished, without aid from Washington or from any outside source except, perhaps, the importation of Commissioner David Lilienthal from a Chicago law office.

First of all, it cracked open the Bell evidence on license fee contracts. The commission did not content itself with observing that the Bell failed to prove the value of service to the extent of 1½ per cent of revenues paid by the Wisconsin subsidiary under its license contract; it went farther and showed up facts about Bell allocation of its expenses to subsidiaries that will take a great deal of explaining.

The company's evidence tended to show that 95 per cent of the sum of all A. T. & T.'s general expenses (that is to say, apart from the long lines department) were allocable to the cost of rendering service to subsidiaries under the license contracts.

Dr. Hubert Havlik, instructor in economics at Columbia University, gives an interesting resume of the way this matter was worked out by the Wisconsin commission. Writing in the current issue of The Journal of Land & Public Utility Economics, he states in part:

"Thus, in effect, virtually only 5 per cent of the A. T. & T. expenses (outside its long distance operating business) was allocated to performance of its functions as a holding company, in which capacity it held in 1934 approximately $1,900,000,000 of common stock in associated telephone companies, which yielded it $115,409,048 in dividends. In contrast, on the above basis of allocating costs, in 1934 the license contract services allocable to associated companies cost $22,029,066, for which the parent company received only $13,389,797.

Hence it seemed to the commission that the apportionment of practically all expenses of the general department of A. T. & T. was predicated upon the belief that the largest corporation in the United States controlled its vast domain and collected hundreds of millions of dollars in dividends annually, simply as incidental and secondary to losing some $8,000,000 in rendering services to associated companies.

The commission was not willing to swallow this assumption and, therefore, likewise considered the A. T. & T. cost allocation untenable. Indeed, the record showed that a substantial portion of the activities of the general department was carried on in behalf of the holding company function of the company, and that assignment of certain taxes and costs of holding funds available for associated companies were clearly not a license contract cost.

On these grounds the commission held that the cost of rendering license contract services had not been shown and, therefore, completely disallowed the 1½ per cent license contract payment as a proper operating expense for rate-making purposes."

IN ADDITION to X-raying Bell's license contract evidence, the Wisconsin commission also made some other bold rulings: (1) with respect to the necessity for book value basis in computing annual depreciation; (2) with respect to the necessity for "consistency" between the amount of depreciation deducted for valuation purposes and the amount of depreciation allowed to be included in operating expenses.

(3) with respect to the alleged "illusory" and "conjectural" character of claims for going concern value; and (4) with respect to a differentiated allowable rate of return (about 6 per cent over all) in the sense that it gives weight to the actual costs of attracting various parts of a utility's capital structure. Not all of these spirited sallies may stand up in court, but there is plenty in the record to fight each point to the last ditch.

Now all this happened out in Wisconsin—not here in Washington—but this correspondent believes that when the final chapter is written, it may have as much effect on telephone regulation *nationally* and on the technique of Federal telephone regulation as it has in Wisconsin. Why?

Well, consider the fact that the leading staff men of the Wisconsin commission who worked on that case have been imported to Washington by the FCC. The same regulatory crew, backed by actual experience of working together in building up the state case is now at work, for the most part on the special Bell telephone investigation.

To this observer this indicates three probabilities which all telephone executives (whether Bell or Independent) would do well to bear in mind: (1) that the FCC investigating staff is really pointing for a national rate case—not just an investigation; (2) that in this rate case (if it should develop) technique similar to that used in the Wisconsin case will likely be employed as to research, evidence, procedure, and perhaps even findings; (3) that if this Wisconsin-Federal technique stands up in court, you can be sure that other commissions will not be slow to follow suit.

It behooves telephone men, therefore, to read these Wisconsin cases, and to watch carefully the developments in court. In the past Wisconsin has led the nation in utility regulation. It may do so again.

COMING CONVENTIONS

The Illinois Telephone Association, Pere Marquette Hotel, Peoria, September 17 and 18.

The Telephone Association of Maine, Poland Springs, September 23; Belfast, September 24; Lakewood, September 25.

Telephone and Telegraph Section, Association of American Railroads, Mayflower Hotel, Washington, D. C., October 6, 7 and 8.

United States Independent Telephone Association, Hotel Stevens, Chicago, October 13, 14, 15 and 16.

Independent Pioneer Telephone Association of the United States, Hotel Stevens, Chicago, October 15.

Indiana Telephone Association, Claypool Hotel, Indianapolis, May 11 and 12, 1937.

Map Shows Independents' Territory in Pennsylvania

The Pennsylvania State Telephone & Traffic Association has compiled and has printed for immediate distribution a telephone map of Pennsylvania. It shows the territory of every operating telephone company in the state, both Independent and Bell. It measures 34 by 22 inches and is printed in three colors.

A recent news bulletin of the Pennsylvania association says: "Every company should have one of these maps on display in every exchange they operate. It will give subscribers and employes a better idea of the magnitude of the Independent industry than anything yet published. 'Seeing is believing' and when you see this map you will believe still more in the soundness of the industry."

The maps are available at cost of $1 each. Since the quantity is limited, those interested in obtaining copies are urged to send their orders in early.

Keeping Down Traffic Errors

By MISS AGNES BRUINS
Chief Operator, Northwestern Telephone Co., Freeport, Ill.

CONSTRUCTIVE suggestions for avoiding many errors which are source of annoyance to the customer and result in service criticisms. Address given before traffic conference during annual convention last fall of The Illinois Telephone Association

THOSE OFFICES classed as observed offices know that the problem of keeping down traffic errors is a minor one because the daily traffic errors that we all experience can be located with the least amount of board supervision. But to those offices where the size of the office does not warrant this advantage, traffic errors can become a real problem to the chief operator and supervisor if they cannot be readily traced.

Most of us, some time or other, have felt that we keep these traffic errors pretty much under control. Then comes a day when numerous errors are made and complaints are handed in and we wonder: "How can my operators be so careless!" A traffic complaint can become an incentive to greater watchfulness to those handling such complaints.

Now that offices of any size have an operator in a supervisory capacity on duty every hour of the day and evening, the errors can be readily pointed out and corrective action taken. This leads us to the importance of maintaining a trained supervisory force at all times.

The chief operator cannot be on duty 24 hours a day, but her methods can be strictly adhered to when the operator in charge has been given proper training. In many cases, this operator in charge occupies a switchboard position; but that does not detract from her authority to give help, take corrective action and assume chief operator responsibility.

What are some of these traffic errors? Each chief operator can almost picture some that have become a part of her daily routine—wrong numbers, cut-offs, slow answers to line signals, slow recalls, careless ringing and overtiming of toll calls. Under the item of wrong numbers, the error is the problem of the individual operator, the real cause being inattention as the subscriber gives the order, carelessness in establishing the connection to the proper number or in watching quadrant markings and noting switchboard changes.

To avoid traffic errors in the magneto type office, greater care should be exercised in the location of the proper line, subsequent ringing and prompt disconnection on receipt of ring-off signals.

Cut-offs due to tangled cords may be avoided in any office by establishing a method of cord rotation and manually associating the cord and disconnect signal with the eye when disconnecting. In the smaller offices where both local and long distance are handled at the same position, the assignment of end cords for long distance cords will prove an advantage for the giving of proper supervision and timing.

Neat switchboard bulletins, noting the discontinued and new telephones as well as temporary changes, should be posted in the small office. This eliminates the errors resulting from trusting to one's memory.

Peg counts, taken regularly, prove themselves invaluable when making up schedules of operators' hours. Be sure that sufficient operators are scheduled to take care of normal loads and subscribers. You will then never need to question the speed of service. The individual office is definitely able to correct any of its major errors by the careful training of all employes.

Train an operator to be telephone conscious of telephony's three salient factors—namely, speed, accuracy and courtesy—and your traffic errors will not be problems but an inspiration toward a new goal of efficiency.

CLAY MOLDING

BY MISS ANNE BARNES,
Traveling Chief Operator, Iowa Independent Telephone Association, Des Moines.

WE ARE TOLD by scientists that the difference between a precious stone, such as a diamond, and a common stone is not in their substance but rather in the organization of the particles of which they are composed. That difference in arrangement makes one a precious stone, the other a common stone.

The downtown streets were full of people this morning—people of many types. So it seemed to me, until I remembered that all people, including myself, were made of the same kind of clay; but how many different kinds of us there appear to be. "What made us different?" I asked myself. And then I thought of the composition of the diamond and the stone.

There were people dressed richly and riding in fine automobiles. There were many more people like myself clad in clothing suitable for going about the everyday affairs of life. There were battered pieces of humanity slouching along the sidewalks and through the stores as though nothing really mattered one way or another. There were happy looking people, gloomy looking people, intelligent looking people and ignorant looking people—all going their different ways of life.

And so I came to the conclusion that we are not different in substance, but what does really make us different—intelligent or ignorant, happy or sad, good or bad, rich or poor—is how we react to life's opportunities. That is what determines whether we shall be a diamond of consequence or a common stone of mediocre value in our community.

Clay does not count for anything out of the ordinary until it is molded into fine usefulness—and such is the telephone operator's usefulness.

There's

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The Type 34A3 self-contained desk Monophone represents the biggest advance made in telephone design in the last decade. The hundreds of telephone companies already using it say it provides a distinctly new and appealing sales story which quickly impresses even the most difficult and "hard to sign" prospect.

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The Operators' Corner

By MRS. MAYME WORKMAN
Traffic Supervisor, The Illinois Telephone Association, Springfield, Ill.

UNIFORMITY of operating practices results in the best possible service for telephone customers. Theories. Series No. 257

EVERY SO OFTEN we find an operator who sincerely believes her customers and different from the average and, therefore, she must use a different method in serving them. This condition is found most frequently among operators employed in small exchanges. Because they are serving people who live in a small community they believe they must not use methods which are employed by "city operators."

A number of years ago, before the advent of the automobile, the radio, hard-surfaced roads, rural electrification and the many other conveniences which are now available to people living on farms and in small communities, these people were more or less isolated. A trip to the city was quite an event and one not indulged in frequently, as it required time to make the journey and it was usually a tedious one.

Under those conditions there was a marked difference in the mode of living of the city dwellers and people residing in rural communities. Not so today! The man in the small village can make a trip to the city by auto in a very short time, his radio keeps him informed of the events of the day, and he is accustomed and familiar with the ways of the city.

He also has occasion to use the city telephone service. In some instances, he may have occasion to use this service in a number of cities, due to the ease and speed with which he may travel. Instead of expecting old-fashioned telephone service, he may be critical of the service in his home town and wonder why its operators do not "pep up" and learn some of those "new-fangled" city ideas.

All telephone customers, whether in the city or village, are quick to perceive any change in the operator's method of serving them and may comment upon the new practice, both favorably and unfavorably. If the comment is unfavorable, the operator should not become discouraged in using the new method. If she is tactful, patient and presevering she will, in most cases, be able to sell the new idea to her customer. Frequently it is merely a matter of educating him to the new practice.

Some operators are prone to be sensitive about comments made by customers, especially those concerning new routines, and are easily discouraged, taking the line of least resistance and going back to the old method.

People living in rural and small communities are entitled to and should have the advantage of modern and improved methods in telephony. The courtesy, speed and accuracy of city telephone service should also be at their disposal.

It is true some modifications may be necessary to fit local conditions but, generally speaking, no distinction should be made between the expressions and phrases used by the city "operator" and the "small-town operator." Both should follow modern standard operating practices as prescribed for their respective exchanges. This will tend towards uniformity which will result in the highest possible quality of service for their respective customers.

Questions from Illinois Operators

1. If a person puts in a call from one town and then cancels the call and places the call from another place, does that call take the rate of the first place or the rate where the party talked from?
2. How can our small-town girls use the city telephone operator expressions and be at ease, knowing that everyone knows just who she is?
3. When placing a call for a certain department in a store or a room in an apartment house, when does it take the person-to-person rate and when a station-to-station rate?
4. What reports are written on the face of the ticket?
5. Should we call subscribers back on busy lines?

The answers to these traffic questions are given on page 31.

When Man in Street "Goes On the Air"

A microphone on a street corner always attracts a crowd, although it has become quite a common sight on the streets of the Nation's Capital, according to The Transmitter, employes' magazine of the Chesapeake & Potomac Telephone Co.

Perhaps you have wondered how the voice of the speaker gets back to the studio. When a broadcasting company desires to consult the man-on-the-street regarding his views on the great issues of the day, it calls the telephone company and states the time and place where it wishes to have a microphone.

A service order is prepared giving all necessary details, including the nearest cable terminal and the cable pair to be used in a certain cable. An installer, armed with tools and material goes to the designated location and, with paired wire, makes the connection from the microphone to the cable. The connection is completed through the central office to a cable pair terminating in the studio from which the voice of the street orator "goes on the air."

▼ ▼

Sunday Toll Business Doubled in Lincoln, Neb.

Studies made by the commercial department of the Lincoln (Neb.) Telephone & Telegraph Co. indicate that a satisfactory increase in Sunday toll business may be secured if employes will aid in calling attention of subscribers to the low rates recently made available. The study concerned itself with calls originating in Lincoln, and showed that while there had been an increase of 9 per cent in general toll business, for the periods considered, there had been an increase of 18 per cent since the low Sunday rate went into effect.

In 1935 a Sunday's toll business was measured as about 42 per cent of a normal weekday. The average of the number of calls handled during the 13 Sundays included in the study made indicated an increase, a Sunday now representing 46 per cent of a normal business day.

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Use Telephone for Facilitating "Curb Service"

Linemen of the Southwestern Bell Telephone Co., working just to the rear of a Ponca City (Okla.) drug store, decided they wanted some cold drinks. They had experience with "curb service" for automobiles so decided to improve upon it by telephoning their order.

Hooking a portable test set onto a line, they placed their order with an astonished and skeptical fountain girl some 30 feet away.

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"Inductive Coordination of Electric Power and Communication Circuits"

by LAURENCE J. CORBETT

Member, American Institute of Electrical Engineers, Fellow, American Association for the Advancement of Science

is the **only one** combining under one cover the essentials of this important subject involving many divisions which have been treated separately and occasionally in numerous reports and articles. It includes results of the author's researches, fitted into a broad survey of the principles applying to Inductive Coordination. It is NOT a compilation of catalog data or undigested reports. It is a carefully developed treatment and clarification of a subject which, though important, has received too little attention. Many diagrams illustrate the practical application of the principles in a manner very readily followed. The variation in values of factors is presented, and theory and practice under these conditions are carefully differentiated.

CHAPTER HEADINGS:

I. Elements of the Problem.
II. Susceptiveness and Coupling Factors.
III. Effects of Conductor Arrangements.
IV. Transpositions.
V. Coordinated Transpositions.
VI. Telephone Circuits on Power Structures.
VII. Power System Wave Shape.
VIII. Transformer Exciting Current and Bank Connections.
IX. Flow of Residual Currents.
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XI. Miscellaneous Values and Remedial Measures.
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Here, There and Everywhere

New Exchange Building for Lincoln, Neb.

The Lincoln Telephone & Telegraph Co. has begun construction of an exchange building to cost $15,000 and located at 4730 South street, in the southeastern section of Lincoln, Neb. It will house a complete new automatic exchange that will serve that part of the city, including the suburbs of College View and Normal, now served with manual equipment.

When the installation is complete, the entire city will be supplied with dial service. Five years ago the company substituted dial for manual service in the northeastern section of the capital city, which includes the suburban communities known as University Place, Bethany and Havelock before being merged with the city proper. Lincoln was one of the first cities in the country to be given automatic service, which was in 1904.

Architect's Sketch Showing Attractive Residential Type Telephone Exchange Building Being Constructed at Lincoln, Neb., By the Lincoln Telephone & Telegraph Co.

The new exchange, as will be seen from the architect's sketch, is of residential type construction designed to harmonize with the architecture in that locality and conforming to zoning requirements. Construction will be completed early next year. The building will be complete in all details, with a lobby and office for payment of accounts, to be supplemented by a collection office in College View.

▼ ▼

Gifford Points Out Improvements in Service

Walter S. Gifford, president of the American Telephone & Telegraph Co., last week made the following statement concerning the long distance telephone rates which became effective September 1:

"The reduction in long distance rates which, on the basis of present business is expected to save the public $7,350,000 annually, is another step in a definite program for better and cheaper long distance telephone service which we have been working on for years.

Only some ten years ago it was necessary to hang up the telephone after placing a call and have the operator call you back later after a delay of five or ten minutes or more; and the cost of a day station-to-station call from New York City to San Francisco, for instance, was $16.50.

Today, nearly all the long distance calls are put through without the person calling hanging up the telephone; and the cost of a telephone call on a week day from New York City to San Francisco is now $7.50, less than half what it was, and is only $4.50 on Sundays and after 7 P. M. In fact, it now costs only $5 on Sundays and after 7 P. M. to make the longest distance call possible within the United States from Eastport, Me., to Bay, Calif., 2,947 air-line miles.

Along with these improvements and economies, there has been marked improvement in the quality of transmission—the conversation being clearer and freer from noises and interruptions.

Many things have contributed to the success of this program of better and cheaper long distance service; research and development applied to physical equipment, improved operating technique, earnings that permitted construction of adequate facilities, and above all, the incentive for accomplishment which is the ideal of the thousands of telephone men and women who have each contributed a part to this progress.

Obviously, the goal is not yet reached, and we shall continue with every expectation that long distance rates may in time be further reduced, and that whatever shortcomings there may be in the service today will be eliminated so far as humanly possible."

▼ ▼

Why Cannot Green Glass Insulators Be Had?

"For nearly a year now our company has found it impossible to procure any glass insulators of the standard color to match existing lines," writes J. F. Hayden, president and manager of the North State Telephone Co., High Point, N. C. "We understand other operating companies have had the same trouble. The factories making glass insulators refuse to supply anything except a strictly colorless glass. For this refusal they assign various reasons, none of which seemingly has any merit.

"Plant men who take a pride in constructing neatly-appearing lines along the public highways, we believe, object to mixing these colorless insulators into their existing lines when making repairs. One would hardly expect all dentists to force their customers to accept a black tooth here and there in making repairs to their teeth.

We believe there is a general demand among the operating companies for a continuation of the standard color of glass, and we believe almost any shade of green would be acceptable, even as pale as that of a Cocoa-Cola bottle.

In the hope of working out some plan to secure glass to match our existing lines, we are asking all operating companies interested to please write a card to the North State Telephone Co., High Point, N. C."

▼ ▼

Bell Telephone System Triumvirate

Harry B. Thayer, former president of the American Telephone & Telegraph Co., who died last week at the age of 78 years, was one of the three principal heads that the company has had since its incorporation in 1885, says Edward J. Condlon in the New York Times of September 6. The others of this triumvirate are Theodore N. Vail, the first president, and the present chief executive, Walter S. Gifford.

The first telephone company was established in New York City in 1877, one year after Alexander Graham Bell demonstrated the practicability of two-way

conversations by wire; Mr. Vail headed the first Bell Telephone company, which had its switchboard at 198 Broadway, just across the street from the present A. T. & T. Building.

At that time a few telegraph poles rose offendingly from the curbstones in the financial district, but in the 1880s, when the telephone company had entrenched itself, the telephone poles with innumerable cross-pieces lined the streets like the shade trees in Peter Stuyvesant's day.

As head of A. T. & T., Mr. Vail conceived the idea of universal service that brought about the national scope of the Bell System with its monopoly over the greater part of the country.

Mr. Thayer, who served as vice-president beginning in 1909, and as president from 1919 to 1925, subsequently becoming chairman, supervised the sending of 25,000 Bell System men overseas at the time of the World War to serve with the United States Signal Corps. Later, his task was to restore service to normal and to push the use of new discoveries.

Progress under Mr. Gifford's leadership since 1925 has been notable, and much of the company's financial strength today is due to his resistance against financial experiments in the form of stock dividends or split-ups, and the avoidance, in the stock boom years, of use of the company's funds for brokers' loans.

▼ ▼

Subscribers Listen to Sermons Over Telephone

It will take more than inclement weather to deny the parishioners of Rev. George E. Youngs and the Nichols (N. Y.) Methodist Church their Sunday morning services of worship—thanks to the arrangements made with the officers of Moore's Telephone System of that city. Many of these church people are residents of Bradford county, Pa., and most of them are telephone subscribers.

All that is required on a severe weather Sunday is a call to the exchange and a request to be "plugged in" to the Rev. Mr. Youngs' service at Nichols.

▲ ▲

Recent Prices in the Metal Markets

New York, N. Y.: Copper—Quiet. Electrolytic, spot and future, 9.75c per lb.; export, 9.77½@9.80c. Tin—Firm. Spot and nearby 44.62½@44.75c per lb.; future, 44.25@44.37½c. Lead—Steady. Spot New York, 4.60@4.65c per lb.; East St. Louis, 4.45c. Zinc—Dull. East St. Louis spot and future, 4.85c per lb. Iron—Quiet. No. 2, f.o.b. eastern Pennsylvania, $20.50 per ton; Buffalo, $19.50; Alabama, $15.50. Aluminum—19.00@22.00c per lb.

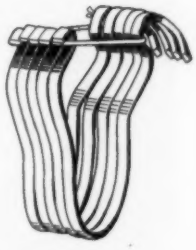
You Can't Beat "NATIONALS"

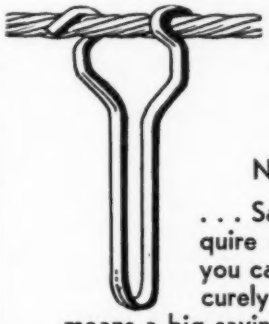
for a Complete Cable Hanging Job

NATIONAL REGULAR RINGS

("The Ring with the Tension Grip")

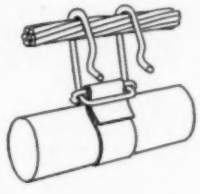
If you would hang the cable with most efficiency and economy you'll use National Rings. These rings have proven their practical value through long years of service. Ask any lineman who has used "Nationals", he'll tell you that they are easily and quickly placed on the strand . . . once placed they remain rigidly in position, never slipping on or jumping off the strand, enabling you to pull the cable either way and doing away with the necessity of reriding to replace or respace rings. Packaged in the "Handy Five" cluster they are very easy to handle and there is no hooking together of rings and no ground litter.





NATIONAL EXTRA LONG RINGS

. . . Save an extra strand when conditions require extra cable facilities for with their use you can hang the additional cable quickly, securely and easily on the same strand. This means a big saving on time, labor and material. Extra long rings have all the advantageous features of the regular rings and are packaged in the same clever practical "Handy Five" clusters.



NATIONAL ZINC CABLE CLIPS

For Replacing Two Rings Either Side of Poles.

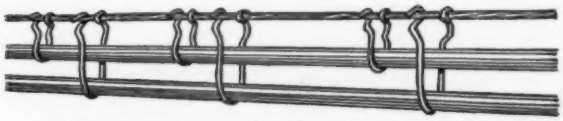


Illustration shows two cables hung from one strand with National Regular and Extra Long Rings.

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Obituaries of Telephone Men

HARRY BATES THAYER, age 78, former president of the American Telephone & Telegraph Co., died at his home in New Canaan, Conn., on September 3. He spent his entire business life with the Bell System and within a few years

HARRY BATES THAYER, Former President of the A. T. & T. Co., and of the Western Electric Co. for Eleven Years From 1908, Whose Business Career Coincided Within a Few Years With the Entire History of the Telephone. He Died at His Home in Connecticut on September 3.

his career coincided with the life and development of the telephone up to the time of his retirement in 1928.

He was with the Western Electric Co. from 1881 and was its president from 1908 to 1919 when he became president of the American Telephone & Telegraph Co. In his association with the Western Electric Co. his relations were mainly with the operating telephone companies rather than with the manufacturing departments.

Mr. Thayer was born at Northfield, Vt., August 17, 1858. He was graduated from Dartmouth College in the class of 1879. His first job after graduation was that of a railway clerk for the Central Vermont Railroad Co. in Bellows Falls, Vt. Later he became a clerk in a Northfield savings bank.

He entered the service of the Western Electric Co. in Chicago in January, 1881, as a shipping clerk at a salary of $10 a week. At that time the company was doing an annual business of about three-quarters of a million dollars. He became president of the Western Electric Co. in 1908. When he left to become president of the American Telephone & Telegraph Co. (June 19, 1919) the annual business of the Western Electric Co. had grown to about $150,000,000.

From the beginning, his activities in the Western Electric Co. pertained largely to the telephone side of that business, which even at that time was beginning to assume very great importance. After three years of faithful work in the telephone field of the Western Electric Co., in Chicago and the west, Mr. Thayer was transferred to New York as manager of the Western Electric Co. in that city.

The performance of his new duties brought him into the closest relations with the telephone officials of this country, and from that time dated his most intimate participation in all of the larger problems which engaged the attention of the telephone companies of the United States.

On February 19, 1902, Mr. Thayer was elected vice-president of the Western Electric Co. and on March 3, 1908, he was elected its president. In February, 1909, he was elected one of the vice-presidents of the American Telephone & Telegraph Co., but continued as president of the Western Electric Co.

During the World War, Mr. Thayer was one of the government's "Dollar-a-year men," being appointed a member of the aircraft board by President Wilson.

When Theodore N. Vail retired as president of the American Telephone & Telegraph Co. on June 19, 1919, to become chairman of its board of directors, Mr. Thayer was elected president of that company. He became chairman of the board of directors January 20, 1925 and retired from the telephone field on August 15, 1928.

During his connection with the Bell System the investment, which was about 25 million dollars at the time he went to work in the manufacturing division, increased to more than 3½ billions.

Mr. Thayer continually acquired friends among the younger men in the telephone field and has always been kindly remembered by them. They will regret his passing and retain their pleasant memories of him during their connection with the industry.

He gave his rules for business success in a talk before the members of the Harvard Business School Club at the Harvard Club in New York City on January 28, 1925. "Give the business you choose a chance'" he said. "Don't give up until you really know something about it." As encouragement to young men working in large corporations, he said that a good man cannot get lost, because there is always a keen lookout for men of ability.

"A chief stumbling block in the way of business success," he said, "arises from failure of the man to forget himself when considering his work. Sometimes it is short-sighted selfishness and sometime it is exaggerated self-esteem."

Mr. Thayer is survived by a son, John Alden Thayer, and two daughters, Mrs. Dorothy Thayer Noble and Mrs. Ruth Thayer Weeks, all of New Canaan. There are eight grandchildren.

▼

ELAM MILLER, staff engineer of the American Telephone & Telegraph Co. died at his home at 133 Summit Avenue, Summit, N. J., on September 2, following a heart attack. Interment was in Columbus, Ohio.

Mr. Miller was born July 14, 1881, in

The Late ELAM MILLER, Staff Engineer, American Telephone & Telegraph Co., Spent His Entire Business Career With the Bell System, Commencing in San Francisco, Calif., in September, 1902.

San Francisco and was educated in the public schools of California and at the University of California.

His entire business career was with the Bell Telephone System. He started with what is now the Pacific Telephone

& Telegraph Co. on September 1 1902, in San Francisco testing cables. In 1904 he organized a material testing laboratory for the Pacific company and in 1907 worked on a development study of the city of San Francisco with the title of second assistant chief engineer.

Mr. Miller went to New York in January of 1912 with the American Telephone & Telegraph Co. and was first engaged in transmission engineering. He was later transferred to the office of the executive vice-president and has since held the title of staff engineer of the American Telephone & Telegraph Co.

Active on various committees of the American Institute of Electrical Engineers, Mr. Miller has published various articles in the technical field. In addition to membership in the Institute,

JAMES E. FINLEY, of Columbus, Ohio, for the Past 11 Years Ohio Representative of Stromberg-Carlson Telephone Mfg. Co., Passed Away Last Week Following an Operation for Appendicitis.

he was an active participant in the activities of the Engineers' Club of New York and Canoe Brook Country Club of Summit, N. J. serving as a member of the board of trustees of the latter club.

Surviving are his wife, and a son, Elam Miller, Jr.

▼

JAMES E. FINLEY, aged 49, since 1925 Ohio sales representative of the Stromberg-Carlson Telephone Mfg. Co., died at the Grant Hospital, Columbus, Ohio, on September 3 following an operation for appendicitis.

Mr. Finley entered the telephone field in 1905 when he was employed by the Stromberg-Carlson company and sent to Syracuse, N. Y., to install equipment in the Independent exchange there. After two years with the Stromberg-Carlson he went to Chicago, obtaining installa-

(*Please turn to page* 31)

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A department store counter, as shown in the illustration above, is a satisfactory and profit producing location. Railroad stations, bus stations, hotel lobbies, gas stations - in fact, any point that the public passes or where people congregate offers EXTRA REVENUE when a pay station is installed.

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GRAY TELEPHONE PAY STATIONS

Telephone Service in Durban, Natal, Union of South Africa

By W. G. TAYLOR
Automatic Electric Co., Ltd., Strowger Works, Liverpool, Eng.

NEW SYSTEM comprising 12 exchanges now in operation. Inner Durban area served by three municipal exchanges and outer area by nine exchanges operated by the Postmaster General. Smaller exchanges of unattended type, serviced from the larger offices. Description of some features of equipment and operation. On the left is shown the automatic equipment in the Malvern office in Durban

FOR THE citizens of Durban, Natal, Union of South Africa, there was marked a further stage in the development of their city when the new Strowger automatic telephone system was opened for service on February 2, 1936. The equipment was designed, manufactured and installed by Automatic Electric Co., Ltd., Liverpool, England, in accordance with specifications issued by the Postmaster General's Department of the Union of South Africa. The design of the equipment is similar to that standardized by the Postmaster General of Great Britain.

Durban is a comparatively young city as it is recorded that the township was laid out only 100 years ago. It was named in honor of Sir Benjamin D'Urban, some time governor of Cape Colony.

In 1910 the first wireless station in South Africa was opened at Durban, and it is, therefore, only in accordance with the progressive spirit evinced in Durban that a modern telephone system should be installed. The municipality owns and operates the local telephone system of the inner Durban area which comprises three exchanges — Central, Tollgate and Stamford Hill. These three exchanges have full interworking with nine in the outer area—Durban North, Overport, Westville, Pinetown, Kloof,

On the Left is the Stamford Building of the Municipal Telephone System of Durban.

Above is the Malvern Building of the Post Office Telephone System in Durban and on the Left is Shown the Durban North Building in Durban.

Attractive Central Exchange Building at Durban, Natal, Union of South Africa.

Hillcrest, Malvern, Rossburgh and Fynnlands, also the trunk exchange at Overport—all operated by the Postmaster General.

Durban is a compact city which covers an area of some 12 square miles. This condition enables the 12 exchanges —the three belonging to the municipality and the nine belonging to the Postmaster General—which have now been cut over to Strowger automatic equipment, to operate as a single system with the Central exchange as the main switching point.

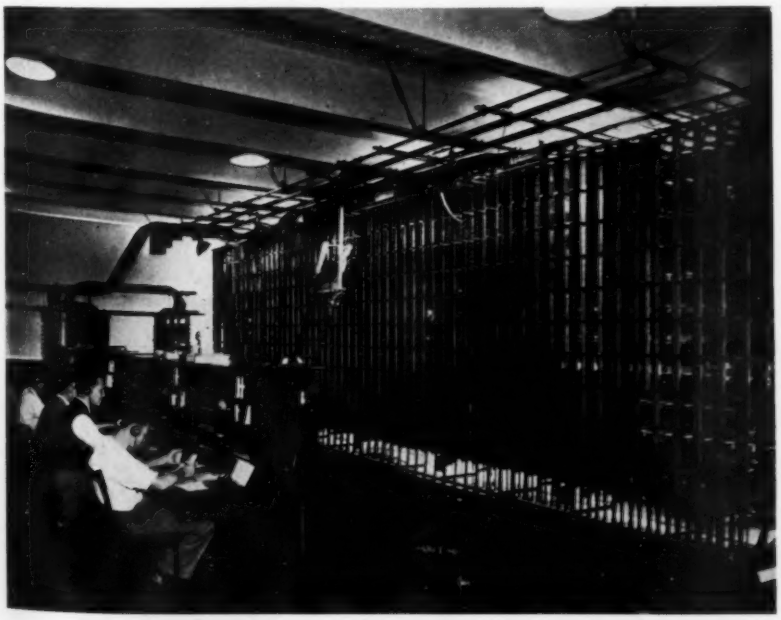
Automatic metering of calls is provided, and for this purpose the area is divided into two zones. Subscribers in the same zone pay a unit fee for intercommunication, but for calls to subscribers in the adjacent zone, two units are registered in the meter. Provision has been made so that as the system grows and the area served becomes more extensive, a third zone will be created. Calls between the first and third zone will be charged three times the unit fee, registration of three units for each of these calls being effected automatically on the calling subscriber's meter.

The 12 exchanges at present accommodate a total of 13,228 subscribers and the multiple has been installed for 14,700 lines. A five-digit numbering system has been adopted for the area. By this system any subscriber making a call to any other in the area dials only five digits, the exchange to which the required subscriber is connected being automatically selected through the digits dialed.

The subscribers' line equipment throughout the area is of the Strowger two-motion line-finder type, arranged in groups of 200 lines for the larger exchanges and in groups of 100 lines for the smaller exchanges.

The smaller exchanges are of the "unattended" type, the exchange equipment operating automatically without attention, except for periodic visits of inspection or in the event of a fault occurring which requires human intervention. Should a fault occur, it would immediately be signaled automatically to a larger exchange where the maintenance staff is on duty and from whence prompt attention can be given.

In the larger exchanges partial secondary finder equipment is installed. This reduces the number of switches which would otherwise be required, by providing individual trunks as primary choices and a common group to absorb the excess when the individual trunks are occupied. The arrangement is such that all the primary finders in a group must be engaged before the secondary finders are brought into use. That is, the regular switches must be used before the "reserve pool" is drawn upon.



Testing Desks and Main Distributing Frame in the Central Office at Durban.

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MADE IN UNITS OF 20 to 20,000 pairs for every type of distribution and service.

Line Terminals — Vertical or Horizontal, 2 to 8 clips high—10 to 50 pairs long.

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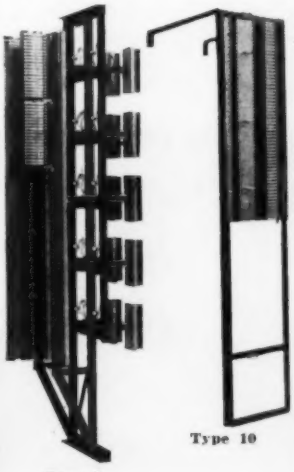
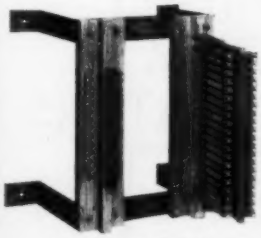
Modernize your plant with a new Cook Frame and Cook Central Office Protectors. Now is the time of the year to make this improvement.



Type I.

Type 10



L-9 Wall Frame

Cook Electric Co.

CHICAGO

To minimize the number of switches and trunks used for a call, digit absorption is effected by the apparatus in accordance with a predetermined plan. On large exchanges of over 1,000 lines only one digit is absorbed because four digits are necessary to complete a local call; but on smaller exchanges of less than 100 lines, it is necessary to absorb three digits because only two digits are required to complete a local call. Each digit absorbed represents a saving of one rank of switches in an exchange.

Discriminating selector repeaters are used to provide full automatic inter-exchange trunking and at the same time to avoid holding junction lines which are not required for conversational purposes.

Facilities are also provided at the Central exchange for call office telephones and for private branch exchanges with more than 10 lines to the Central exchange. To deal with special services such as time, faults, enquiry, complaints, phonegrams, etc., manually-operated switchboards are provided at the Central and Overport exchanges.

A special emergency service is given to all subscribers in the area who dial 80. This service is dealt with by the manual board at Central, as is also interception for subscribers' incoming service check and changed numbers.

Automatic Equipment in the Tollgate Office of the Municipal System in Durban.

The area is provided with two separate test desks—one at Central and the other at Overport—to deal with the testing on municipal and government exchanges, respectively.

Centralized observation service is also provided at the Central and Overport exchanges for the respective exchanges of the municipality and government. By this service the operation of the subscribers' meters can be checked as well as the progress of incoming and outgoing calls, if required.

In the large exchanges—Central, Tollgate and Stamford Hill—automatic routine testing equipment is provided. This apparatus proves the correct operation of each switch in turn, to which it is automatically connected. Should a switch not perform any one of its functions correctly, the automatic tester stops and gives an appropriate alarm.

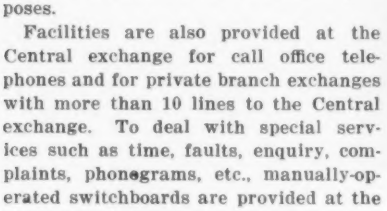
All long distance trunk and toll calls are dealt with on the trunk manual board at Overport, except incoming traffic from Pietermaritzburg, Umkomaas and Port Shepstone. This traffic is dialed-in direct to Durban subscribers by the distant trunk operators via the dialing-in equipment and the train of trunk equipment provided at each exchange in the area.

To meet the increased demand for long distance calls which arises as a result of the improved local service, arrangements are being made to give an "on demand" service. By this service subscribers are enabled to obtain long distance connections with almost the same celerity as local connections.

A subscriber calling the long distance (trunk or toll) operator gives the required number and holds the line while the connection is established if the distant subscriber is disengaged. Should the number be engaged, connection is established when the required number becomes disengaged.

A service of this kind naturally takes time to develop, because in addition to necessary alterations on the long distance switchboard, many miles of long distance lines are required.

The present time witnesses a growing appreciation of telephone service for business and social purposes. The telephone user of today is not confined to one town, country or continent; the whole world is his exchange and there are now few places where telephone service is not available. For this reason the whole world is interested in the modernization of any particular system since the subscribers connected thereto are potential telephone correspondents and the quality of the apparatus determines the ease with which such conversations can be maintained.



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Largest Independent MANUFACTURER of TELEPHONE BOOTHS
CHURCHILL CABINET CO.
Chicago New York

Condensed Telephone News

Telephones

CHICAGO, ILL.—Telephones in service in Chicago showed a net gain of 3,758 during August, the Illinois Bell Telephone Co. reports. At the close of the month there were 876,450 telephones in use. In the preceding month there was a net gain of 2,070 in telephones in service in the city.

LINCOLN, NEB.—Revised figures of the Lincoln Telephone & Telegraph Co. show a net station gain for the first six months of the year of 1,025 as compared with a net gain of 639 for the same period in 1935. Over 44 per cent of all the employes made sales. In the Lincoln district the percentage was 60, York district 5 per cent, and more than 50 per cent in Beatrice and Hastings districts. The traffic department led, with the plant department second.

Outward toll messages in the six months were 737,922, an increase of 10.1 per cent and Postal Telegraph outward messages 40,639, an increase of 9.6 per cent.

NEW YORK, N. Y.—The New York Telephone Co. during August had a net gain of 9,855 stations, compared with a loss of 1,987 telephones in the like month of 1935. The August, 1934, loss was 4,868 stations with a loss of 7,009 in August, 1933.

For the eight months to August 31 the company had a net gain of 42,941 stations, against a net loss of 8,155 stations in similar months of 1935, a loss of 7,072 in the eight months of 1934 and a loss of 127,186 in the like period of 1933.

PHILADELPHIA, PA.—The Bell Telephone Co. of Pennsylvania reports that preliminary figures show a net gain of 3,087 telephones in service for August. In August, 1935, the company reported a gain of 775 telephones, compared with a loss of 381 in August, 1934, and a loss of 2,281 in August, 1933.

The net gain for the first eight months is 30,053 telephones compared with a gain of 6,843 for like period of 1935. As of August 31, there were 1,101,501 Bell telephones in service in Pennsylvania.

Construction

COLUMBUS, OHIO—The Ohio Bell Telephone Co., according to a recent announcement, will spend $16,800 in new construction to provide additional facilities for subscribers in what is known as the Driving Park section in southeast Columbus. The work, which is expected to be completed before the end of the present year, will consist of the placing of 5,000 feet of aerial telephone cable 4,200 feet of underground cable and installing about 1,400 trench feet of new conduit.

The new cables will provide feeder facilities for the sparsely developed area from Lilley avenue east to Alum Creek and south of Livingston avenue. The additional facilities will accommodate future telephone growth in this area.

Financial

SAN FRANCISCO, CALIF.—The Pacific Telephone & Telegraph Co. on September 4 declared a dividend of $2 a share on the common stock payable on September 30 to stock of record of September 19. It has been paying $1.50 quarterly. President N. R. Powley said the directors had been influenced by consideration of improved earnings and also the undistributed profits tax. However, the declaration did not establish a rate. The directors also declared the regular quarterly dividend of $1.50 a share on the preferred stock, payable on October 15 to stock of record of September 30.

NEW YORK, N. Y.—Directors of the Western Electric Co., Inc. on September 8 declared a dividend of 75 cents a share on the company's common stock. This will give the A. T. & T. Co. about $4,500,000 as it owns practically all the stock. The dividend is payable September 30. A payment of 50 cents a share was made on June 30, the first dividend in several years. At its Hawthorne plant near Chicago the company now has about 12,500 persons at work.

Miscellaneous

RHINE, GA.—Mr. and Mrs J. S. Conley, Jr., have purchased the Rhine telephone exchange from the Southeastern Telephone Co. of Georgia.

J. S. Conley, formerly with the Southeastern company, assumed charge of the exchange at Milan.

SHELBY, IOWA—Lester Larson of Shelby has returned to Albia, his former home, to become manager of the local exchange there of the Iowa State Telephone Co., replacing W. G. McAvoy.

AUBURN, NEB.—Mrs. L. N. Corrington, cashier for 14 years at the local exchange of the Lincoln Telephone & Telegraph Co., has resigned and been succeeded by Miss Karina Jezewski, who has been employed for 11 years in the traffic department. Mrs. Corrington was one of the company's most efficient and valued employes.

Obituary

BROWNSBURG, IND.—Clyde L. Cummings, age 61, owner and manager of the Brownsburg Telephone Co., was found dead in the workshop of the telephone building on August 27. Mr. Cummings had been in charge of the Brownsburg exchange for a number of years and had been in the telephone business practically all of his life. He had served the Bell company in Kansas and also had been owner of an exchange in that state. He was prominent in both church and civic affairs of his community. Death was due to heart failure.

DELAWARE, OHIO—A. A. Welch, age 52, manager of the Northern Ohio Telephone Co. here, was found shot to death late on September 1. A rifle was at his side. His widow said he had been in ill health. A former telephone official in Elyria and Oberlin, he had worked in the Delaware exchange for 20 years.

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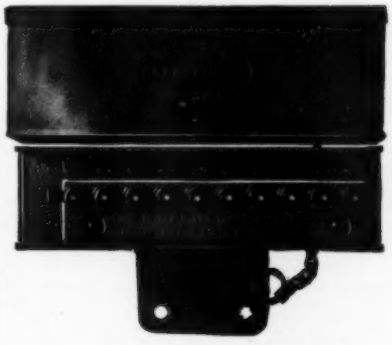

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"Telephony's" Engineering Data

By B. C. BURDEN

Index, Vacuum Tube Practice.
Sept. 12, 1936.
No. 11-A, Page 5.

The mutual conductance or grid shift test stimulates the conditions under which tubes are normally used as distinguished from the emission test which determines the ability of a tube filament or cathode to emit a large number of electrons. Those who have studied vacuum tube theory know that the term "mutual conductance" defines the *ratio between a change in plate current and the small change in grid voltage producing this plate current change.* This relationship is shown in equation form as:

$$G_m = \frac{I_p}{E_g}$$

where:
G_m = mutual conductance in mhos;
I_p = plate current change in amperes;
E_g = grid voltage change in volts.

As an example of how this works out numerically, suppose in a given type of tube we change the grid voltage from a negative 10 volts to a negative 5 volts, or a total change in grid voltage of five volts. The resulting plate current changes from 20 milliamperes to 40 milliamperes or a change of 20 milliamperes. The mutual conductance of such a tube would, therefore, be .02 divided by 5 or .004 mhos (4,000 micro-mho).

As an example of the difference in typical mutual conductances of various radio receiving tubes, a type 56 (triode amplifier) has a mutual conductance of 1,450 micro-mho, while a type 47 (pentode amplifier) has a mutual conductance of 2,500 micro-mhos. This does not mean that the type 47 is a better tube than the type 56 as the two tubes are designed for entirely different purposes. It does mean, however, that the type 47 has a higher plate current change for a given grid voltage change than the type 56.

If two type 56 tubes were compared, one having a mutual conductance of 1,450 and the other of only 800, the tube having the higher mutual conductance would be by far the better tube. If this fact is clearly appreciated, the general features of mutual conductance testing will be better appreciated.

Theory of Mutual Conductance Tube Tests

Mutual conductance or grid shift type tests, when boiled down to their simplest essentials, consist mainly of an arrangement whereby a voltage—somewhat comparable to that used in the normal operation of a given tube—is applied to

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the plate and the screen grid, and where the control grid voltage is changed from some initial value to some different value by depressing a key which varies the grid voltage. A milliammeter in series with the plate of the tube shows an increase in plate current, the value of which determines whether or not the tube is in a satisfactory operating condition.

Many tube testers, especially those designed exclusively for service men, utilize regular milliammeters which are calibrated to read in milliamperes. Data showing the differ-

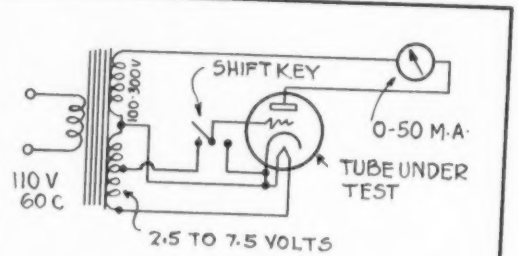

FIG. 2. GRID SHIFT TEST CIRCUIT

ence reading between the initial and the higher plate reading after the grid voltage is shifted is given for tubes considered in good condition. Tubes failing to come up to this requirement are, of course, unsatisfactory and should be replaced with new tubes.

The present trend in the grid shift type testers is to have a large meter with a colored scale which is so marked as to indicate directly whether a tube is good or bad. This type tube tester is often referred to as the "English reading" type of tube tester. The advantage over the other type is their simplicity and the fact that the public has more confidence in them, as they are themselves able to tell by the meter deflection whether or not a tube is good or bad.

There are several methods by means of which the grid voltage can be shifted in a tube tester. One method is to utilize a small "C" battery, this method being employed in some of the early tube testers. Another method is to shift the grid return from one point on the filament heating winding to another point of higher positive potential. Even though

"Telephony's" Engineering Data

By B. C. BURDEN

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Sept. 12, 1936.
No. 11-A, Page 7.

alternating current be used for filament and plate supply, the operation of this method is not affected, provided the connection is so made that the grid is positive at the same instant that the plate is positive.

Still another method of shifting the grid voltage is to utilize a dropping resistor in series with the cathode or filament of the tube under test and shift the grid return from one point to another point on this dropping resistor, which, of course, changes the grid bias. Fig. 2 illustrates the mutual conductance type of test circuit.

Miscellaneous Tests of Vacuum Tubes

In addition to the straight electrical and mutual conductance tests, it is generally desirable to have tube testers so equipped that tests of the gas content of a tube may be made. The high efficiency of present-day vacuum tubes is due in a large part to their high vacuum. The air in tubes is pumped out at the factory and they are then heated until red hot by means of an intense high-frequency field. This tends to drive all gas out of the tube elements, after which further pumping takes place.

Oftentimes tubes, which contain some gas, slip by. These tubes eventually find their way into radio receiving sets. Such tubes are generally erratic performers and will cause a radio set to misbehave. They are often quite difficult to locate. It should be understood that the term "gas" is merely another way of saying "air."

If a tube contains sufficient gas and if the voltage at which a tube is operated is fairly high, the gas may make itself known by a slightly bluish glow within the tube. This glow is due to the electrons passing from filament to plate, colliding with the gas atoms and causing them to become ionized. However, in many cases sufficient gas may be present to interfere with the proper operation of a tube and yet not be evident by the bluish glow.

Gas in a tube is bad for several reasons. In the first place, the relationship between grid voltage and plate current changes may not be a linear one, due to the fact that the electrons traveling from filament to plate collide with the gas atoms, resulting in new electrons being created by collision (referred to as "secondary electrons"), and these electrons travel on to the plate with the normal electrons, thus increasing the plate current. Inasmuch as the collision effect is more or less haphazard, distortion may result.

OBITUARIES OF TELEPHONE MEN

(*Concluded from page 25*)

tion work with the Chicago Telephone Co.

In 1909 Mr. Finley transferred to the New York Telephone Co. and for the following nine years was engaged in central office inspection and testing work with that company and the Western Electric Co. He returned to installation work with the Stromberg-Carlson company in 1916 and, with the exception of two years with the Junction City (Kans.) Telephone Co. and the Citizens' Independent Telephone Co. at Terre Haute Ind., had been with it since.

He became sales representative in Ohio for Stromberg-Carlson in 1925 and in 1930 was made its senior representative in that state with headquarters in Columbus. Mr. Finley was well known throughout Ohio and his many friends were greatly shocked to learn of his untimely death. He was a member of the Independent Pioneer Telephone Association of the United States.

Mr. Finley is survived by his widow, Mabel E., a son and two sisters.

▼ ▼

District Meetings Scheduled for Iowa

Chas. C. Deering, of Des Moines, Iowa, secretary of the Iowa Independent Telephone Association, announces that the association will hold district meetings as follows: September 22 at Manning; September 23 at Remsen; September 24 at Emmetsburg; and September 25, Fort Dodge.

Answers to Traffic Questions on Page 20

1. The rate in effect between the towns from which conversation takes place will apply on the call.
2. Please refer to preface of the questions on page 20.
3. The person-to-person rate applies if a PBX operator is reached at the called station and she rings the department or room. The station-to-station rate applies if, when the called station answers, the department or room requested is reached.
4. The reports received by the CLR operator or the operator making the first attempt on the call.
5. Only in those cases where the customer requests you to do so and it is the practice in your office to comply with these requests.

some of the early tube testers. Another method is to shift the grid return from one point on the filament heating winding to another point of higher positive potential. Even though

down to their simplest essentials, consist mainly of an arrangement whereby a voltage—somewhat comparable to that used in the normal operation of a given tube—is applied to

trons travel on to the plate with the normal electrons, thus increasing the plate current. Inasmuch as the collision effect is more or less haphazard, distortion may result.

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International Creosoting and Construction Co., Galveston, Texas — Creosoted Southern Yellow Pine Poles. Plants: Beaumont and Texarkana, Texas.

Jordan Bros. Lumber Co., Box 84, Norfolk, Va.—Virginia White Cedar Poles. Plain or charred and creo-treated butts.

MacGillis & Gibbs Company, Milwaukee, Wis.—Northern White and Western Red Cedar Poles. Plain or butt-treated. Immediate quotations on request.

T. M. Partridge Lumber Co., Minneapolis, Minn.—Northern White—Western Red Cedar Poles. Plain or butt treated.

H. Sigalet & Company, Ltd., Lumby, B. C., Canada—Western Red Cedar Poles. Plain or Butt treated.

Valentine Clark Corporation, 2516 Doswell Ave., St. Paul, Minn.—Finished Cedar Poles. Plain or Butt treated.

Commission and Court Activities

Oklahoma Commission to Probe Bartlesville Rates

The Oklahoma Corporation Commission, according to newspaper dispatches last week, will launch at once its investigation of the rates and charges of the Southwestern Bell Telephone Co. in its Bartlesville exchange. This is part of the commission's statewide investigation of the Southwestern Bell.

The engineers of the commission will commence at once an appraisal study of the Bartlesville exchange and the auditors are expected to begin work in about a month.

▼ ▼

Ohio Associated to Issue New Bonds

On September 4 the Ohio Public Utilities Commission authorized the Ohio Associated Telephone Co. to issue new first mortgage bonds bearing not to exceed 4½ per cent interest and to be sold at not less than par, also to issue a demand note of not to exceed $100,000 to make the refunding. It was specified that the discount and expenses carried in discounts as to issue of present bonds, $32,000 odd, the premiums paid and all expenses connected with the new issue, be amortized during the remainder of the life of the present bonds. A further condition is that pending such amortization, $170,000 of the company's present $192,000 surplus be frozen against the distribution of dividends on outstanding common stock.

The authority was granted by the commission upon the application of the telephone company which has outstanding $1,770,000 first mortgage 6 per cent bonds due in 1963 and which are callable to 105, to issue at cost not to exceed 4.6 per cent, $1,770,000 new first mortgage 30 year bonds dated December 1, 1936, and bearing not to exceed 4½ per cent interest, and to issue a 5 per cent demand note to the General Telephone Corp. of New York to enable the calling of present bonds on January 1, 1937.

▼ ▼

Ohio Associated Wins Counter Suit

The Ohio Associated Telephone Co. won a verdict in a suit brought against it by M. E. Miller of Marion, Ohio, following a trial before a petit jury in common pleas court. Judge Hector S. Young directed the jury to dismiss the Miller petition and return a verdict for the telephone company on its cross petition for a back telephone bill. The judge awarded judgment in the amount of $105.40 to the company.

Mr. Miller had sued for $2,999, for damages allegedly suffered by reason of loss of telephone service and inconvenience in his business because the company refused to furnish him with a telephone at his residence.

In his petition, Mr. Miller alleged that the telephone company had agreed to furnish him with free telephone service as long as he permitted a pole and "dead man" to remain on his property. He complained that after they were left on the property approximately two years the company billed him for $117 for back telephone service.

At the close of the plaintiff's evidence Judge Young ordered Mr. Miller's petition dismissed on the grounds that the contract for free home service, if there was such a contract, was void and illegal under Ohio law because the law prohibits discriminatory rates. The judge held that a utility cannot give one resident free service or a lower rate than it gives to others.

After the Miller petition was thrown out the telephone company, represented by Attorneys Russell M. Wilhelm and Kenneth A. Robinson, presented evidence to show the amount Mr. Miller owed the company for back telephone service, which was discontinued at his residence in September of 1934. The judge directed the jury to return a verdict for the telephone company, on which he rendered judgment for $105.40.

▼ ▼

Commission Rulings and Schedule of Hearings

Federal Communications Commission Washington, D. C.

September 28: Hearing before Telephone Division on the examiner's report in the case of the Rochester Telephone Corp., of Rochester, N. Y., in which it was recommended that the company be subject to federal regulations because it "is deemed to be under the indirect control of the Bell companies" (TELEPHONY of July 18, page 28).

October 5: Hearing before examiner of Telephone Division at Hotel Goldman in Fort Smith, Ark., in the case of the Oklahoma-Arkansas Telephone Co. against the Southwestern Bell Telephone Co. concerning the latter's installation

of a toll board at Poteau, Okla., and the complications arising therefrom.

Arkansas Department of Public Utilities

August 19: Southwestern Bell Telephone Co. filed notice that effective September 15 it will eliminate the extra charge of 15 cents per month on telephones of the handset type where customers had handsets installed two years ago or longer.

September 14: Hearing postponed to this date on a rule of the Southwestern Bell Telephone Co. under which it reserves the right to install coin-box or pay telephones in semi-public places where business telephones may be available for use by the public.

The hearing originated at Fort Smith, where the city commission passed an ordinance making it a misdemeanor to install a coin type telephone without the consent of the owner of the business. Enforcement of the ordinance has been ordered held in abeyance by the commission pending the hearing, and the scope of the investigation widened to include all cities and towns where the Bell System operates in the state.

Illinois Commerce Commission

September 9: Hearing in Springfield on complaint of the Eldorado Lions Club, the Federal Wholesale Corp., James Coleman, N. Schwartz, Wm. F. Johnson, Robert Lindsay and James Nameth against the Illinois Commercial Telephone Co., concerning service rendered by it to telephone patrons in Eldorado.

September 9: Hearing in Springfield on complaint of the city of Columbia, Monroe County, and the Commercial Club of Columbia, against the Farmers Fountain Telephone Co. and the Harrisonville Telephone Co., as to re-establishment of physical connection for continuous line of communication between the mentioned telephone companies, investigation of rates, charges, service and equipment in Columbia.

September 9: Hearings in Springfield on application of the Illinois Bell Telephone Co. for authority to purchase from the American Telephone & Telegraph Co. two teletypewriters and associated equipment located in Moline and Ottawa.

September 9: Hearing in Springfield on citation of the commission on its own motion against the Assumption Mutual Telephone Co. to show cause for the discontinuance of telephone communication facilities between Assumption and Westervelt.

Missouri Public Service Commission

September 3: Approval granted application of the Missouri Union Telephone Co. to issue mortgage notes.

Nebraska State Railway Commission

August 28: Application of the Cambridge Telephone Co. to fix rates for handset type service found reasonable and granted as asked.

August 28: In the matter of the applications of E. C. Hunt to purchase certain exchanges of the Western Telephone Corp. and of the newly-organized Public Telephone Co. to purchase these properties from Mr. Hunt; found to be reasonable and authority granted as asked, which includes permission for the Public Telephone Co. to issue $40,000 of bonds and $25,000 of stock.

August 31: In the matter of the application of the Lincoln Telephone & Telegraph Co. for validation of a $1.50 rural service rate at Deweese; dismissed, matter having been covered in a previous order.

August 31: In the matter of the application of the Lincoln Telephone & Telegraph Co. for validation of $6-a-year service station rate at its Johnson exchange; it appearing that rate had been charged and collected by an oversight, request granted.

September 1: Applications filed by the Hershey Telephone Co. for authority to sell its exchange to Glenn Fletcher and of Mr. Fletcher to purchase property of Sutherland-Fairview Telephone Co.; set for hearing September 30.

September 1: In the matter of the application of the Central Nebraska Telephone Co. for authority to extend for a stated period emergency rates in effect at its Brady and Maxwell exchanges; found reasonable and granted as asked.

Ohio Public Utilities Commission

September 3: The Ohio Bell Telephone Co. authorized, by supplements to its current tariff for Burton, Cedarville, Conesville, Fletcher, Franklin, Fremont-Lindsay, Gallipolis, Ironton, Lena, Murray City, Navarre, South Charleston, South Solon, West Lafayette and West Jefferson exchanges, to allow the discount for prompt payment regardless of the date of the payment of current bills.

September 4: Ohio Associated Telephone Co. authorized, under certain conditions, to issue new first mortgage bonds bearing not more than 4½ per cent interest and to be sold at not less than par, and also to issue a demand not to exceed $100,000.

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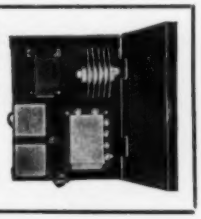

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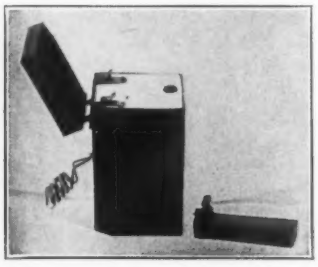

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EXPERIENCED line and repair man wants work or will lease a place on monthly payments. Go anywhere; good references. Address 8554, care of TELEPHONY.

POSITION WANTED—Young man, telegraph and telephone inside maintenance and engineering experience. Have excellent record in Bell, foreign and international service. Address 8488, care of TELEPHONY.

EXPERIENCED line, switchboard and instrument repair man wants work. Independent company. Good reference. Will go any place. Address 8487, care of TELEPHONY.

POSITION WANTED—Wire chief or troubleman, local or common battery. Married. Claude R. Wiandt, Rt. 6, Jackson, Tenn.

POSITION WANTED—Seven years' Bell traffic experience, university graduate, age 31. Thorough knowledge of modern engineering and operating practices, dial and manual; administrative duties. Address 8511, care of TELEPHONY.

Independent Pioneers' "Evening at Night Club"

Since announcement was made that the annual entertainment of Independent Pioneer Telephone Association of the United States will be held in the evening this year in the form of "An Evening at a Night Club," many favorable comments have been received by members of the organization's entertainment committee.

The general plans for the evening include a dinner during which music will be furnished by one of Chicago's excellent stage and dance orchestras. Specialty numbers will be rendered by the orchestra which will also provide music for dancing and for the floor show.

The floor show will include an announcer having a reputation for wit and comedy, a brother and sister dance team presenting grace and rhythm in simple and acrobatic dance steps, an imitator of exceptional cleverness, a novelty comedy act which will appeal to the risibilities of old and young, a group of eight dancing girls whose beauty and grace in executing their presentations has won high favor among night club patrons; and other artists with acts of high standards.

The plans call for a continuous program of music and entertainment, interspersed with dancing during the intermission between the two sections of the floor show and following it, until midnight or later.

Arrangements will soon be completed so that table reservations may be secured in advance of arrival in Chicago for Independent Telephone Week. As tables will seat eight persons, it is suggested that Independent Pioneers and their friends arrange as soon as possible groups for that evening so that table reservation tickets may be obtained when the advance sale opens.

The price of tickets which includes dinner, entertainment and dancing—an entire evening's enjoyment—has been set at $3 each. As tables will be assigned in the order of the receipt of the reservations, those intending to be with the Independent Pioneers for "An Evening at a Night Club," will form their table groups now so as to send their table reservations in when the first announcement is made of their being available.

It is expected this year's Independent Pioneers' meeting will establish new records in attendance, standard of entertainment, enjoyment and friendship. It will be held on Thursday, October 15, at the Stevens Hotel, Chicago, during the week when the Independent telephone industry is gathered for the annual convention of the United States Independent Telephone Association.